Title

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A Case Study of the 2017 and 2018 California Wildfires

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ABSTRACT

Ensuring social equity in evacuations and disasters remains a critical challenge for many emergency management and transportation agencies. Recent sharing economy advances – including transportation network companies (TNCs, also known as ridehailing and ridesourcing), carsharing, and homesharing – may supplement public resources and ensure more equitable evacuations. To explore the social equity implications of the sharing economy in disasters, we conducted four focus groups (n=37) of vulnerable populations impacted by California wildfires in 2017 or 2018. To structure these data, we employed the **S**patial **T**emporal **E**conomic **P**hysiological **S**ocial (STEPS) equity framework in an evacuation context. We contribute to the literature by: 1) summarizing the focus groups and their opinions on the sharing economy in evacuations; 2) capturing wildfire evacuation obstacles through the STEPS transportation equity framework; and 3) linking STEPS and focus group results to explore the future potential of shared resources. Using STEPS, we also expand our shared resource exploration to 18 vulnerable groups.

We found that all focus groups were highly concerned with driver availability and reliability and the ability of vehicles to reach evacuation zones, not necessarily safety and security. Each group also expressed specific limitations related to their vulnerability. For example, individuals with disabilities were most concerned with inaccessible vehicles and homes. Using the STEPS framework, we found that while multiple vulnerable groups could gain considerable benefits from shared resources, 10 of the 18 groups experience three or more key challenges to implementation. We offer several policy recommendations to address equity-driven planning and shared resource limitations.

Keywords: Evacuations, Sharing Economy, Transportation Network Companies, Homesharing, Social Equity, Vulnerable Populations

1. INTRODUCTION

In recent years, the United States (U.S.) has been severely impacted by multiple large-scale disasters, requiring evacuations to safeguard residents. Multiple large and destructive hurricanes in 2017 and 2018 including Hurricanes Harvey, Irma, Maria, Florence, and Michael led to the evacuation of millions of people. Fast-moving wildfires in California including the October 2017 Northern California Wildfires and the December 2017 Southern California Wildfires, along with the Mendocino Complex, Carr, Camp, Hill, and Woolsey wildfires, led to the evacuation of thousands. Even with the rise in disasters, many transportation and emergency management agencies remain unprepared to transport and shelter all citizens in disasters, mostly due to a lack of necessary resources and assets. Consequently, some citizens – particularly those most vulnerable such as the carless – are unable to evacuate in a disaster. Other vulnerable groups including older adults, individuals with disabilities, low-income households, and non-English speaking households, struggle to receive information about evacuations and find adequate transportation and sheltering. Recent research has found that one third of the 50 largest cities in the U.S. do not have an evacuation plan (Renne and Mayorga, 2018). Moreover, of those cities that do have a plan, just half mention carless or vulnerable populations (Renne and Mayorga, 2018). To ensure equitable evacuations, new strategies will need to be employed to increase assets and safely transport and shelter vulnerable populations.

Along with an increase in disasters and evacuations, the sharing economy – consisting of Internet-based transactions to share and obtain goods – has grown rapidly in the past decade. This growth has been most apparent in the sharing economy companies in transportation (e.g., Uber, Lyft, Zipcar) and hospitality (e.g., Airbnb, VRBO). Since Hurricane Sandy in 2012, many of these companies have been actively involved in disaster response and relief (Wong et al., 2018; Wong et al., 2020a). Recent research has also found that individual citizens are moderately willing to offer shared resources to evacuees for future disasters (Wong et al., 2020a). Given the rise of the sharing economy in evacuations and encouraging research on its feasibility, we hypothesize that shared resources – from private companies or private citizens – could be one tool to develop more equitable evacuations.

In this paper, we address both the equity benefits and limitations of the sharing economy in evacuations. We expand on focus group results presented in Wong and Shaheen (2019) to emphasize the research in the broader evacuation and equity literature and employ the **S**patial **T**emporal **E**conomic **P**hysiological **S**ocial (STEPS) framework. We guide this research through several questions including:

1. What social equity challenges do individuals face in evacuations?
2. What is the opinion of vulnerable groups on the sharing economy under disaster conditions?
3. What are the key benefits and limitations of the sharing economy for specific vulnerable groups? Are shared resources more feasible for certain groups?

We answer these questions through results from four vulnerable population focus groups of individuals impacted by California wildfires in 2017 or 2018, which we conducted from August 2018 to March 2019; an application of the STEPS transportation equity framework (Shaheen et al., 2017); and an exploration of the equity implications of shared resources. We first present a

literature review focused on social equity in evacuations, providing the framing of how a shared resource strategy could improve social equity challenges. We then describe our research methodology and its limitations. Next, we present the results of the four vulnerable population focus groups. We then link the focus groups and STEPS framework to present the benefits and limitations of shared resources across 18 different vulnerable groups. Finally, we offer policy recommendations for agencies to improve social equity for shared resources in evacuations.

2. LITERATURE REVIEW

2.1 The Sharing Economy and Shared Resources

With improved technology and communication ability, the sharing economy has grown rapidly in the past 10 years. It consists of peer-to-peer (P2P) or business-to-consumer (B2C) transactions via the Internet where goods and services are shared and obtained. Enabled through information and communication technologies (ICT), P2P and B2C services are transforming the built environment and how individuals interact with goods and services. However, several key challenges to shared behavior and engaging with the sharing economy include: business model sustainability, labor exploitation, limited consumer protection, disregard of regulation, and social equity challenges.

2.2 Shared Housing, Shared Mobility, and Social Equity

With the rise of companies, such as Airbnb and HomeAway, homesharing has become a major sector of the sharing economy. Typically, these services are used as short-term accommodations when traveling and offer a lower cost option to more traditional hospitality services, such as hotels. Recent research has also begun to look at homesharing impacts within the sharing economy. For example, research has found that Airbnb has had a causal and negative impact on hotel revenue, particularly on lower-priced hotels (Byers et al., 2013; Zervas et al., 2017).

Shared mobility is an innovative transportation strategy where users are typically able to access shared vehicles, bicycles, or other modes on an as-needed basis (Shaheen et al., 2016). It employs variable cost mechanisms that can offer individuals greater choice, lower costs, and increased convenience for transportation. Recent literature has provided an overview of many of these different shared mobility options, such as transportation network companies (TNCs, also known as ridehailing and ridesourcing), carsharing, ridesharing, and bikesharing (e.g., Shaheen et al., 2016; Rayle et al., 2016; Shaheen and Cohen, 2013; Chan and Shaheen, 2012; Furuhata et al., 2013; Shaheen et al., 2010) and the impacts of these options on cities and transportation (Meyer and Shaheen, 2017). A list and description of many shared mobility options can be found in Shaheen et al. (2016).

Since the emergence of the sharing economy, several studies have addressed the potential for shared mobility to serve as a more equitable transportation mode. Studies including Rauch et al. (2015) and Shaheen et al. (2017) have proposed that shared mobility is a pathway to increase accessibility, reduce auto travel costs, and allow more flexible travel patterns. Use of shared mobility as a strategy for addressing transportation equity concerns also extends into policy and planning practice (Shaheen et al., 2017). Shaheen et al. (2017) note the limitations that can arise from shared mobility in serving low-income, older adult, and disabled populations. The lack of technology access – or the digital divide – remains a primary barrier for equitable shared mobility. Prices for shared mobility also remain high under many circumstances, and vehicles are often not well-equipped for those with disabilities and may not provide equitable access in lower-income

and/or lower-density neighborhoods. Further, there has been ongoing research on shared mobility and sheltering regarding discrimination (Ge et al., 2016; Edelman et al., 2017). Equity issues in consumer protection, privacy, safety, and worker rights also persist.

2.3 Social Equity and Resource Deficiencies in Evacuations

Social equity has also been a critical area of concern in evacuations. The lack of equitable evacuation and emergency planning was most acutely clear during Hurricane Katrina in New Orleans, Louisiana in 2005 (Wolshon, 2002; Renne, 2006). Many of these equity lessons learned are summarized in Litman (2006). Hurricane Katrina exposed severe resource deficiencies for some vulnerable populations; estimates of 127,000 to 300,00 people in the New Orleans Metropolitan area did not have access to reliable transportation (Wolshon, 2002; Boyd et al., 2009). An estimated 100,000 people did not evacuate prior to Hurricane Katrina and required transportation assistance following landfall (Boyd et al., 2009). Consequently, New Orleans now offers emergency transportation to carless individuals through its city-assisted evacuation plan, which maps pickup points and leverages city assets such as buses (The City of New Orleans, 2018). However, New Orleans remains an outlier for planning for vulnerable populations, as noted in Renne and Mayoraga (2018). More work is also needed to assess how vulnerable populations would make choices, such as Sadri et al. (2014) for mode choice. One complication of the disaster planning process, however, is that the definition of a vulnerable population is variable based on the state, region, and city (Turner et al., 2010). Developing effective communication strategies for evacuation orders and available resources presents a challenge given the diversity of vulnerable groups and how they are defined. Moreover, frameworks on equity through the lens of social vulnerability (see Cutter et al., 2003 for an overview) sometimes cover both social and place inequality. These different dimensions of inequality require a more holistic understanding of the barriers faced by vulnerable populations in evacuations. Comprehensive reviews of the social equity literature in disaster relief can be found in Perry (1987), Fothergill et al. (1999), Cahalan and Renne (2007), Sorensen and Sorensen (2007), Renne et al. (2008), Sanchez and Brenman (2008), Renne et al. (2009), and Rodriguez et al. (2017).

2.4 Recent Social Equity and Resource Deficiencies in Wildfire Evacuations

Recently, a series of wildfires in California have led to mass evacuations, devastating damage, and tragic loss of life. In many cases, the speed of wildfire quickly overcame evacuees, and governments had difficulty deciding where and when to issue evacuation orders and how to manage transportation systems during the evacuation (Watkins et al., 2017; Lewis et al., 2018; Nicas et al., 2018). These wildfires also impact areas along the urban-wildland interface (WUI), which is the zone of land that runs alongside unoccupied wildland and human development. Often, communities along the WUI have few transportation options, and most citizens had to rely on personal vehicle to evacuate. In several cases, smaller public transit agencies including Sonoma-Marin Area Rail Transit (SMART), Vine Transit, and the Santa Rosa CityBus were able to assist in evacuating several hundred evacuees in the October 2017 Northern California Wildfires (SMART Train, 2017; Napa Valley Register, 2017; ABC7, 2017). For the 2017 December Southern California Wildfires, Gold Coast Transit and Santa Barbara Metropolitan Transit District were also able to assist in the evacuation of citizens (Gold Coast Transit, 2017; Brugger, 2017). However, for most wildfire evacuees, personal vehicles were the only option available. In addition, individuals impacted by the Carr Fire, Mendocino Complex Fire, and the Camp Fire (all in 2018)

had little to no access to public transportation in their area, leaving those without vehicles behind (Nicas et al., 2018).

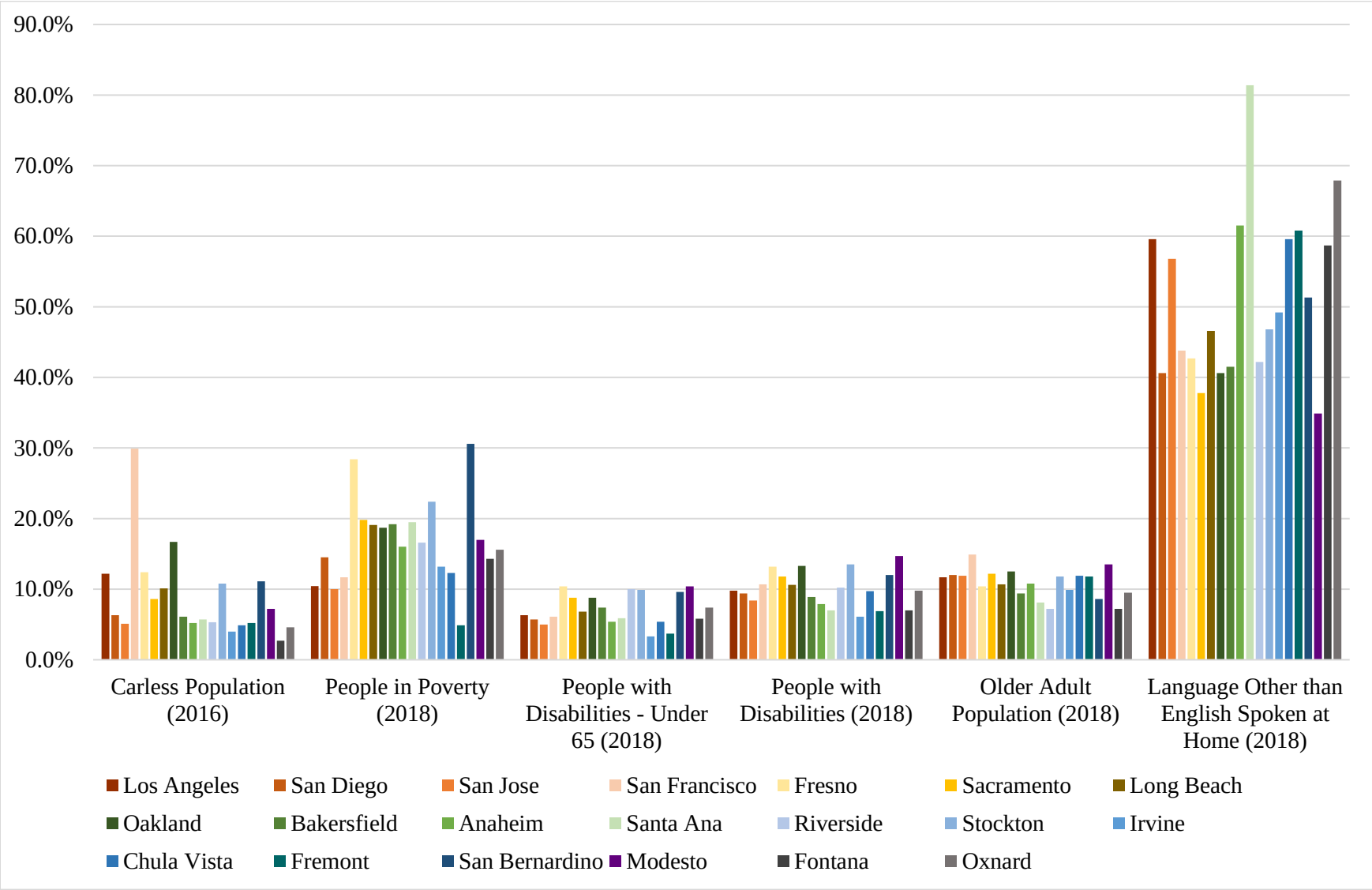
This lack of transportation access is not just an issue for smaller cities in California. As seen in Figure 1, a significant number of individuals in the 20 largest major cities in California are carless (U.S. Census Bureau, 2019). Moreover, multiple California cities also have a high percentage of other vulnerable groups (e.g., low-income, individuals with disabilities, older adult, and non-English speaking). While not all individuals in these cities would be impacted by a wildfire (or series of wildfires), the data indicates severe challenges in successfully evacuating vulnerable groups from even a smaller area. Without an adequate amount of public resources for these vulnerable groups, new strategies must be considered and activated when necessary for future disaster events in California and beyond.

2.5 A Sharing Economy Strategy for Evacuations

To address these resource deficiencies and social equity problems, it is possible that the sharing economy and shared resources from companies and private citizens could be leveraged to increase the number assets available in evacuations. While research has identified a number of benefits to this strategy (e.g., increasing compliance, quickening the evacuation process, and serving vulnerable populations), limitations still persist regarding the liability, cost, and structure of the strategy (Wong et al., 2018; Wong et al., 2020a). Li et al. (2018) produced a comprehensive study of the evacuation feasibility of DiDi, a TNC based in China, and also acknowledges notable sharing economy limitations. This research, along with Wong and Shaheen (2019), offers policy recommendations on how to leverage shared resources. Most recently, research using stated preference data for no-notice evacuations found that a TNC strategy could be extremely effective for highly urgent evacuations (Borowski and Stathopoulos, 2020). The research also offered an extensive commentary on leveraging TNCs in evacuations, explaining the benefits and limitations of the strategy, particularly for more urban areas.

However, work on determining how a shared resource strategy could improve (or hurt) equitable outcomes in evacuation remains severely limited. We build upon research started in Wong and Shaheen (2019) to determine if a shared resource strategy can produce more equitable outcomes for vulnerable populations. Consequently, we contribute to the evacuation literature by: 1) assessing the obstacles faced by individuals in evacuations, 2) offering evidence through focus groups of vulnerable populations on the impacts of shared resource strategies, and 3) providing practice-ready recommendations for agencies to improve equitable outcomes. Through this research, we begin to understand and develop a more equitable shared resource strategy as a possible tool in evacuations and disaster recovery efforts.

Figure 1. Vulnerable Population Percentages for the 20 Largest California Cities (Listed in Order of Population)



3. RESEARCH METHODOLOGY

To assess the obstacles faced by individuals in evacuations, we employed the STEPS transportation equity framework on the dimensions of **S**patial, **T**emporal, **E**conomic, **P**hysiological, and **S**ocial equity. This framework, developed in Shaheen et al. (2017), takes a holistic and theoretical approach to determining the various dimensions of transportation equity. The framework was originally developed for shared mobility, as barriers along the STEPS dimensions were among the most debilitating for using these transportation services. However, the dimensions are easily expandable to other transportation areas, such as evacuation and recovery efforts, as seen in Table 1.

We note that Cutter et al. (2003) developed a framework for social vulnerability across multiple dimensions, while Vink et al. (2014) used some dimensions to quantitatively estimate the number of vulnerable individuals from a flood evacuation. While we recognize the benefits of these frameworks, we employed STEPS to more closely align transportation equity concerns with a narrower evacuation/recovery context. Moreover, the STEPS framework was originally crafted to overcome key deficiencies in identifying barriers to shared mobility, which is the primary transportation area considered in this paper. For this paper, we employed this framework under wildfire evacuations to explore the equity implications for different vulnerable groups. We note that numerous equity implications are consistent across disasters, and this framework can also be applied for other major disasters (e.g., hurricanes).

Table 1. STEPS Equity Framework for Transportation and Wildfire Evacuations

Dimension	Original Definition for Transportation Equity	Application for Wildfire Evacuations
Spatial 	Spatial factors that compromise daily travel needs (e.g., excessively long distances between destinations, lack of public transit within walking distance)	Spatial factors that increase risk, increase evacuation distances, decrease routing options, or compromise evacuations (e.g., single exit routes, high risk fire zones, lack of public transit within walking distance, low proximity to resources, shelters located far away)
Temporal 	Travel time barriers that inhibit a user from completing time-sensitive trips, such as arriving to work (e.g. public transit reliability issues, limited operating hours, traffic congestion)	Travel time barriers that inhibit a user from departing at a reasonable time, reaching a destination at an appropriate time, evacuation time costs that lead to non-compliance, or early returners to impacted areas (e.g., additional mobilization time due to medical needs or packing, minimal communication notification, roadway congestion, rapid fire spreading due to wind, public transit reliability issues, work requirements)
Economic 	Direct costs (e.g., fares, tolls, vehicle ownership costs) and indirect costs (e.g., smartphone, Internet, credit card access) that create economic hardship or	Direct and indirect costs that create economic hardships or preclude users from evacuating (e.g., hotel/supplies/gasoline costs, vehicle ownership

	preclude users from completing basic travel	costs, time away from job especially for hourly employees)
Physiological 	Physical and cognitive limitations that make using standard transportation modes difficult or impossible (e.g., infants, older adults, and disabled)	Physical and cognitive limitations that make using standard transportation modes or sheltering resources difficult or impossible for specific groups (e.g., vulnerable groups including older adults, individuals with disabilities, homebound individuals, etc.; inability/challenge to receive evacuation information due to visual/auditory disability; needing to use accessible vehicles or shelter)
Social 	Social, cultural, safety, and language barriers that inhibit a user's comfort with employing transportation (e.g. neighborhood crime, poorly targeted marketing, lack of multi-language information)	Social, cultural, safety, and language barriers that inhibit a user's comfort or ability in using transportation or evacuating (e.g., vulnerable groups including racial and ethnic minorities, immigrants, undocumented immigrants, Native American and Indian Tribal governments, etc.; lack of multi-language information on evacuation orders, transportation, and sheltering; discrimination in resource allocation)

We supplement the STEPS framework through four focus groups that we conducted from August 2018 to March 2019 of individuals impacted by three different California wildfires in 2017 or 2018 (Table 2). We found participants through related post-disaster surveys and outreach performed by local agencies, news outlets, and community-based organizations (CBOs). In these focus groups, we met with individuals from vulnerable groups to gain insights on the choices that they made throughout the evacuation process, their current use of the sharing economy, and their opinions on leveraging shared resources for future evacuations. Our goal was to interview a wide range of vulnerable groups affected by different fires to gain a broader perspective on the equity impacts of evacuations and the feasibility of the sharing economy as a strategy to expand resources. While each wildfire had unique characteristics and differing governmental response, all wildfires were fast-moving, required mass evacuations, and impacted citizens living on the WUI.

Table 2. California Wildfire Focus Group Overview

Focus Group Population	Focus Group Eligibility	Wildfire	Number of Participants	Focus Group Location & Date
Older Adult	65 years or older	2017 Oct. Northern California	10	Rohnert Park, California (Aug. 2018)
Individuals with Disabilities	Disability or family member with a disability	2017 Oct. Northern California	10	Rohnert Park, California (Aug. 2018)
Low-Income	2017 household income below $40,000	2017 Dec. Southern California	8	Ventura, California (Aug. 2018)

Spanish-Speaking	Speak Spanish in the household	2018 Mendocino Complex	9	Lakeport, California (Apr. 2019)

We specifically developed these groups to collect information from vulnerable populations who experience additional challenges and barriers in an evacuation. We considered conducting research using a survey to increase size. However, we found that our associated surveys on individuals impacted by wildfires severely undersampled vulnerable populations and diminished any understanding of how vulnerable populations would interact with shared resources. In addition, a survey method for vulnerable individuals using in-person, mail, phone, and online communication would have required significant monetary resources that were unavailable to the team. These focus groups were conducted in direct response to the undersampling in our wildfire surveys.

We defined each focus group population to broadly reflect the vulnerable groups most impacted by the chosen wildfires (2017 Northern California Wildfires, 2017 Southern California Wildfires, 2018 Mendocino Complex Wildfire). Individuals in three of the focus groups were first contacted through their participation in related surveys for the 2017 Northern California and 2017 Southern California Wildfire surveys. The groups (each with a maximum of 10 people) were filled first using the survey participants and then with additional participants found through local partner agencies. We worked with partner agencies to identify both focus group locations and participants. These partners were contacted based on their experience with the wildfires (e.g., local emergency management and transportation agencies), ability to reach a wide population (e.g., news media), or work with vulnerable populations (e.g., community-based organizations and non-governmental organizations). Partner agencies were encouraged to advertise the focus groups across online platforms and in-person connections. We also provided a web-based and telephone-based recruiting tool for participants to sign up. We formed the Spanish-speaking focus group for the Mendocino Complex Wildfire solely through partnering agencies, since we did not distribute a prior survey there (as we did in the other three focus groups). All participants were incentivized with a $100 gift card and the Spanish-speaking focus group was conducted only in Spanish.

4. STUDY LIMITATIONS

This study leverages insights from four qualitative focus groups, which represent a small sample of the overall population. Thus, these individuals are not representative of the general population or even the subset vulnerable group. The focus groups exhibit a self-selection bias as individuals opt into the study. Individuals may have been less forthcoming within the focus group context, particularly given that the researcher was present and focus group members may have learned about the group via communication from a governmental agency. For some groups and especially the Spanish-speaking focus group, the lack of knowledge of sharing economy resources or the ability to use resources led to few responses. We also acknowledge that a sharing economy strategy for the California wildfires context may not be applicable for wildfires in other geographies, let alone different hazards. We strongly recommend that research and strategies for improving equitable outcomes is highly localized, as demographic characteristics differ greatly even between neighborhoods. Different hazards also pose different equity challenges. The STEPS framework, while used here in the wildfire context, can be extended for other disasters (e.g., hurricanes, tornados) to more clearly identify transportation equity dimensions. We also note that the list of vulnerable groups, while extensive, does not fully encompass all individuals (e.g., children,

incarcerated individuals). We decided to leave these individuals out of the sharing economy analysis as they would be unable to participate solely in such a strategy. We also do not provide a full overview of other limitations of the sharing economy (reviews in Wong et al., 2018; Li et al., 2018; Borowski and Stathopoulos, 2020; and Wong et al., 2020a). For example, communication and power outages could severely hamper matching of individuals for rides or shelter.

Another important limitation of this study is the sample size of only four focus groups. While we achieved a focus group size (between 4 and 12 participants) that is consistent with literature (Carlsen and Glenton, 2011), we likely did not reach saturation of themes and topics for each specific demographic. Empirical research has found that between five (Coenen et al., 2012) to eight (Kirchberger et al., 2009) focus groups are needed to achieve data saturation (i.e., point in data collection when little to no new information is provided, see Guest et al., 2006 for additional overview). Literature has also found that for a homogenous set of participants, 80% of themes could be discovered within two or three focus groups (Guest et al., 2017). However, we note that our focus groups were not homogenous, and we intentionally constructed our groups using different vulnerable populations. This diminishes our ability to make definitive conclusions about each specific vulnerable population.

Despite this limitation, the groups still provided insights on the equity implications of the sharing economy, and more thematic saturation of the sharing economy in evacuations across a group of individuals impacted by wildfires may have been reached. We also note that we were unable to conduct more focus groups due to study resource constraints, as well as identifying enough research subjects. Indeed, only the older adult and individuals with disability focus groups had two and three alternates, respectively. These low numbers also occurred despite considerable outreach to at least five agencies and CBOs per focus group. The limitation also speaks to the broader challenge of recruiting vulnerable populations in research, particularly during recovery periods after disasters. Given our limited resources, we chose to recruit a variety of vulnerable populations to explore more general themes on how shared resources could be beneficial (or problematic) in evacuations. Our design was also guided by the challenge that vulnerable groups are often not represented or accounted for in the disaster or emergency planning process (as noted in the literature review). Overall, since each focus group is not representative of the related vulnerable group, additional research for each vulnerable group will be needed to assess generalizability. However, we note that the purpose of focus groups was not to achieve generalizability, rather it was to uncover possible themes, opinions, and discussions that could serve as a stepping stone for future work on social equity and sharing economy strategies.

Finally, we acknowledge that most focus group participants had never used TNCs or homesharing for evacuation/recovery purposes. This limitation is largely a result of the relatively new presence of the sharing economy, the lack of sharing economy pilots in disaster, and the somewhat limited overlap of company service areas and disasters. We did not specifically seek out focus group participants who had used the sharing economy during the wildfires, as we would have been unable to find enough participants. Consequently, this diminishes the thought-experiment of asking participants to discuss how the sharing economy could be used in an evacuation. However, most participants either had experience or knowledge of TNCs and/or homesharing under normal conditions that allowed them to make more informed opinions. The Spanish-speaking group, with

very limited experience, did not thoroughly discuss how companies could assist, but instead it focused on community members helping other community members.

5. FOCUS GROUP RESULTS

We conducted four focus groups with different vulnerable groups – older adults, individuals with disabilities, low-income individuals, and Spanish-speaking individuals– across several California wildfires from August 2018 to March 2019. We note that individuals in these groups often overlap (i.e., an older adult with a disability), but we encouraged individuals to focus on their specified group's barriers. As noted in Table 3, most participants across groups evacuated from their respective wildfire and a sizable number also lost their homes. However, not everyone received a mandatory evacuation order, indicating severe communication problems. We found that a majority of older adults and low-income participants used TNCs and homesharing before. This is likely an overrepresentation, particularly for TNCs, as research has found older adults compared to other ages are less likely to take TNCs (Brown, 2018). While experience for low-income individuals is also likely overrepresented, about 24% of Lyft users lived in Los Angeles neighborhoods with a mean income of below $38,000 (Brown, 2018). We also note that some respondents said that their experience with TNCs was more related to shared rides to the airport (e.g., an airport shuttle). In addition, the focus group geographies for the older adult and low-income groups were in areas where TNCs are available and near major cities (i.e., San Francisco, Los Angeles) in which TNCs are heavily used. The older adult group in the San Francisco Bay Area also has access to several other TNC services, including Women Driving Women and Silver Ride (a service for seniors).

No Spanish-speaking participant used TNCs, which is likely due to the rural setting of the Mendocino Complex Wildfire. Low-income individuals had considerable knowledge of Airbnb Open Homes, a program that encourages hosts to provide free shelter to evacuees. Out of the 37 participants, only one evacuee used TNCs during the evacuation while just two used homesharing. One possible explanation for such low usage is that all the wildfires were either in small cities or rural geographies where sharing economy companies are less active. Another explanation is that the cost of shared resources, particularly TNCs, could have made the option cost prohibitive. Finally, participants may have first sought other resources (for example their own vehicles or a public shelter). Indeed, participants may not have known if sharing economy resources would be available, especially since this evacuation/recovery strategy was not promoted or organized by local agencies. We also note that even though few individuals used the sharing economy during an evacuation, individuals still largely had knowledge of the sharing economy, indicating its potential as a resource pool for future disasters.

Table 3. Vulnerable Population Focus Group Characteristics

Focus Group Population	Older Adult	Individuals with Disabilities	Low-Income	Spanish-Speaking
Sample Size	**10**	**10**	**8**	**9**
Participant Characteristics				
Evacuated from Wildfire	9	10	6	8
Received Mandatory Evacuation Order	3	4	4	6
Lost Home in Wildfires	4	4	3	0
Sharing Economy Characteristics	N=10	N=10	N=8	N=8*
Used TNCs Before	50%	30%	63%	0%
Used Homesharing Before	60%	50%	50%	38%
Knowledge of Airbnb Open Homes	20%	30%	63%	38%
Used TNCs for Wildfire	0%	10%	0%	0%
Used Homesharing for Wildfire	10%	0%	13%	0%

** One participant had to leave before the sharing economy discussion*

5.1 The Sharing Economy in Evacuations

We asked participants to share their opinions of leveraging the sharing economy in evacuations. During this time, we encouraged participants to describe how their evacuation process might be improved or worsened with the sharing economy. Participants were also told to consider both private companies and private citizens as providers of transportation or sheltering resources. The results are summarized in Table 6, which provides the limitations and benefits of TNCs and homesharing, along with the general view of the group on the shared resource strategy. We offer a brief commentary for each group.

Table 6. Benefits and Limitations of Sharing Economy Resources for Evacuations

	Older Adult	Individuals with Disabilities	Low-Income	Spanish Speaking
View of TNCs in Disasters	Mostly negative	Mostly negative	Largely split	Largely split
TNC Benefits	• Real-time mapping and location of drivers • Added resources for relief period • Rides to medical appointments or to gather supplies	• Added resources for relief period • Rides to medical appointments or to gather supplies	• Could be integrated into a larger multi-modal strategy • Assist underserved populations	• Assist carless • Reduce cost of fuel • Increase resources for vulnerable populations, including older adults
TNC Limitations	• Driver availability and reliability • Impact of wildfires on drivers' families • Low willingness of drivers to go into harm's way	• Vehicles not accessible • Low communication accessibility on platforms • Cost prohibitive	• No driver incentive to assist • Inability to reach evacuation zone • Increase in congestion and travel time	• Difficult to communicate resources to public • Lack of Spanish translations • Low trust of drivers and companies

	• Added confusion to the evacuation process • Presence may not substantially increase resource availability	• Ride cancellation potential • Lack of driver training, especially for emergency situations	• Cost prohibitive • Unavailable to those without smartphones connected to a bank	• Requires knowledge of using the Internet and smartphone
View of Homesharing in Disasters	Somewhat positive	Largely split	Somewhat positive	Somewhat negative
Homesharing Benefits	• Suitable shelter in an evacuation • Allow non-impacted individuals to volunteer	• More comfortable than public shelter • Easier access to food • Allow non-impacted individuals to volunteer	• Escape smoke • Suitable shelter in an evacuation and opportunity to leverage more resources	• More comfortable than public shelters, especially for children and pets • Better access to basic household goods
Homesharing Limitations	• None provided by participants	• Poor accessibility for disabilities • Lack of host training • Poor home layout • Lack of necessary medical equipment • Issues with host communication without Internet or smartphones	• Possible legal consequences regarding short-term rental laws	• Rather stay with friends and family • Low trust of host and strangers • Communication challenges with notifying evacuees in Spanish • Poor credentialing process

5.1.1 Older Adults

Overall, older adults did not have a positive outlook on using private companies as a strategy, particularly for sharing rides. Participants were most concerned about drivers and their availability/reliability. This spatial and temporal problem was expanded on, as older adults explained that drivers may also be impacted by the wildfires, may not want to drive into harm's way, and could add confusion to the evacuation process. Still, some older adults explained that mobility platforms could be helpful in a disaster, since the applications could provide real-time mapping and information about the location of drivers. Older adults were more supportive of a government run strategy (social dimension). Moreover, they preferred if drivers were not impacted by the wildfire (spatial dimension) and if costs could be kept low (economic dimension). Finally, they preferred if the sharing economy strategy was implemented during the relief and recovery period, rather than during the evacuation period. Overall, older adults favored a neighborhood network of volunteers that would function similarly to carpooling.

Older adults were more positive about homesharing and mostly found that Airbnb would be a suitable platform to provide sheltering resources in a wildfire. One participant explained that hosting through Airbnb would allow non-impacted community members to volunteer and be part of the recovery process. Airbnb sheltering could also be tax deductible and might encourage more individuals to sign up to host. The shorter discussion and lack of key limitations on homesharing indicates a more favorable view of homesharing in wildfires. Indeed, one older adult used homesharing during the evacuation and found it be a helpful resource.

5.1.2 Individuals with Disabilities

The individuals with disabilities group was also negative on leveraging TNCs in an evacuation. Multiple participants explained that sharing economy companies are largely not disability-friendly and do not provide accessibility in the form of communication or vehicles (physiological dimension). They also noted that these services could be cost-prohibitive, especially when compared to lower-cost paratransit. Participants also expressed concern over reliability as some individuals had experienced cancelled rides under normal circumstances (temporal dimension). Individuals with disabilities preferred to support a strategy that created a clear partnership between paratransit and private companies to minimize some of the concerns over reliability and driver training. They also recommended that mobility platform applications be able to document a rider's disability (for both general and evacuation rides) along with any service animal needs (for evacuation rides).

Homesharing limitations largely mirrored concerns with TNCs, specifically on accessibility for disabilities (physiological dimension) and knowledge of hosts (social dimension). Homesharing hosts might not have the equipment or home layout to accommodate an individual with a disability and may not be trained to assist the individual. It would also be challenging to communicate the availability of homes without smartphones or Internet connection. Overall, participants explained that homesharing could be much more comfortable than a public shelter and allow for easier access to food. Individuals with disabilities also noted that homesharing could be a way for concerned community members to volunteer.

5.1.3 Low-Income Individuals

Most low-income participants were highly skeptical of using TNCs. Specifically, they did not think that drivers would have an incentive to help in an evacuation (economic dimension) or would be unable to reach evacuees due to blocked off or reversed roads (spatial dimension). Participants were concerned that TNCs might increase congestion and travel times (spatial and temporal dimensions) and that evacuees would be unable to pay, especially without a bank account or smartphone application (economic dimension). Participants strongly believed that any shared mobility strategy should be coupled with a stronger and broader multi-modal strategy. A public transit system, along with shared resources, could be especially helpful for other underserved populations in the area (i.e., Ventura County) such the Hispanic community.

For homesharing, only one participant in the low-income focus group used Airbnb (in this case to escape smoke). However, multiple participants noted that their friends and acquaintances had positive experiences with using the platform for housing following the wildfires. Several participants said that they thought homesharing would be a good platform to leverage for additional resources. A recommendation was also made in reforming short-term rental laws, allowing people to volunteer in an emergency without fear of legal ramifications. The shorter discussion on homesharing indicates that a relief strategy using homesharing is more feasibility and preferred by low-income individuals.

5.1.4 Spanish-Speaking Individuals

Most Spanish-speaking participants had little experience with TNCs and homesharing, particularly through private companies. One key emergent theme was that many participants were willing providers of transportation, housing, and food throughout the wildfires, indicating that they were

attempting to fill key social dimension equity gaps. Some participants also said that they would be willing to offer a ride to neighbors. The discussion of providing resources is notable since members of the other focus groups concentrated on being receivers of resources.

When asked about benefits and limitations, participants explained that transportation would have been helpful for carless evacuees who had to walk during the evacuations. Sharing transportation might also reduce the cost of fuel and increase resources for other vulnerable populations (e.g., older adults and individuals with disabilities). However, participants expressed distrust of private companies and drivers (social dimension) and had little knowledge of the companies or how they would use the service via a smartphone or the Internet (social and economic dimension). One critical limitation would be the language of communication as Spanish (both written and spoken) would have to be a priority (social dimension).

Trust remained a key theme for homesharing as participants held a generally negative view of a sheltering strategy. Spanish-speaking participants explained that they were more likely to stay with friends and family and would not trust strangers (social dimension). Despite a negative view of public shelters (which may lack Spanish translators, basic household goods, and safety), Spanish-speaking participants did not think that a homesharing strategy through a company (such as Airbnb) would be an adequate substitute in its current form. Indeed, the communication challenges with notifying the public of available housing would diminish the effectiveness of the program. A few participants emphasized that resources were described but only in English for the recent wildfires, making it difficult for Spanish-speakers to find the resources.

5.2 Overall Observations

In our discussion with four vulnerable groups, most participants exhibited mixed or negative reactions to TNCs as a shared resource strategy in evacuations. Despite noting a number of limitations (e.g., driver reliability, availability, cost, communication challenges), participants were also quick to make recommendations for a general TNC strategy. All groups noted that any future shared resource strategy for transportation should:

- Plan in advance using well established protocols and by disseminating resource information;
- Build a community-driven approach (neighbors helping neighbors);
- Focus on the recovery period following the evacuation; and
- Train drivers to assist all people in disaster situations.

For homesharing, older adults and low-income participants were more positive while individuals with disabilities and Spanish-speaking participants were more negative. Interestingly, recommendations for a shared resource strategy were highly group specific and were not as fully discussed as TNCs, perhaps due to a greater need to develop transportation strategies. Overall, we note that while many participants had adverse reactions to the sharing economy at the beginning of the conversation, most had more positive thoughts about a shared resource strategy, after offering their own recommendations and improvements (Table 7).

Table 7. Recommendations Provided by Focus Groups for Developing a Sharing Economy Strategy

	Older Adult	Individuals with Disabilities	Low-Income	Spanish-Speaking
General TNC Strategies	• Plan in advance using well-established protocols and by disseminating resource information • Build a community-driven approach (neighbors helping neighbors) • Focus on the recovery period following the evacuation • Train drivers to assist all people in disaster situations			
Group Specific TNC Strategies	• Partner with local governments • Use drivers who live in unimpacted zones • Ensure that costs remain low (no surge pricing)	• Create partnerships with paratransit that could identify and assist individuals with disabilities • Include an option in the application to denote disability or service animal owner	• Create coordination between emergency services and companies to send drivers • Develop multi-modal system that prioritizes public transit with private companies fulfilling first-mile, last-mile	• Provide information on available resources in Spanish • Include credentialing information for drivers to increase trust • Increase emergency education to encourage sharing across the community
Group Specific Strategies for Homesharing	• Offer a tax deduction for providing home to evacuees	• Distribute information about available resources across multiple platforms • Leverage pre-existing senior care and homeless shelter options and expertise	• Reform short-term rental laws to increase supply of homes	• Provide information on available resources in Spanish • Include credentialing information for hosts to increase trust for renters

6. VULNERABLE POPULATION MATRIX – LINKING STEPS AND FOCUS GROUPS

Using the STEPS framework, we constructed Table 8 to reflect vulnerable populations in evacuations. We provide the percent of the California population according to the American Community Survey 2012 to 2016 (five-year estimates) (US Census Bureau, 2019), if those figures were available. In addition to the applicable STEPS dimensions, we present the benefits and challenges of the sharing economy for each group as a *receiver of shared resources* via icons. A short feasibility analysis is also given to highlight if shared resources would be easy to implement, effective, and equitable for specific groups. We finish the table with recommendations derived from the focus group results and STEPS. Different vulnerable groups including carless; asset poor; racial and ethnic minorities; older adult; immigrants; LGBTQ+ individuals; and required workers have a higher feasibility for implementation. These groups tend to have higher access to technology to leverage shared resources and have a more varied range of income levels, which gives them advantages in a disaster. Several groups including those who are unbanked (or underbanked), individuals with disabilities, hospital bound, undocumented immigrants, and homeless were rated on the low end. While shared resources would greatly benefit these groups, a number of challenges exist related to locating these populations and ensuring they can engage with shared platforms. Indeed, all 18 identified vulnerable groups have at least one challenge for implementing shared resources, and ten groups have at least three major challenges.

Table 8. Vulnerable Groups Matrix

Vulnerable Group	Definition	Primary STEPS Dimensions	American Community Survey (% of California Residents)	Vulnerable Group as a Recipient of Shared Resources			
				Shared Resource Opportunities	Shared Resource Challenges	Analysis and Feasibility	Recommendations based on Focus Groups and STEPS Framework
Carless	Do not own a personal auto vehicle	Spatial Temporal Economic	7.7% do not own a vehicle			Carless populations range from those without resources to own a vehicle to those in dense environments who choose to forgo car ownership. There is a wide range of opportunities, and this group has higher technology usage than other groups. However, challenges exist locating the population and not having enough capacity to evacuate enough people.	Develop multi-modal system that prioritizes public transit with private companies fulfilling first-mile, last-mile Disseminate resource information ahead of time to encourage compliance Create system with meeting points for different resources (e.g., rides to shelters, medical attention)
Low-Income	Under the poverty line based on household size; may also include individuals who do not earn a living wage	Economic	13.3% are below the poverty line			Low-income individuals often choose to not evacuate due to the high costs. Shared sheltering is the clearest benefit for reducing costs and increasing the number of resources available should aid in both evacuating and sheltering. However, low-income individuals typically have less access to technology and may be subjected to price gouging.	Develop multi-modal system that prioritizes public transit with private companies fulfilling first-mile, last-mile Ensure that prices are kept low (no surge) or provide resources for free to evacuees Disseminate information about resources (e.g., assistance filing insurance claims, free air masks) during reentry phase

Unbanked and Underbanked	Do not have a bank account and/or a credit or debit card	Economic	Not available			Similar to low-income, unbanked individuals could benefit substantially from reduced costs of sheltering and transportation. However, without access to a bank or credit card, they will most likely be unable to pay if the service is not free. They also have lower rates of technology usage.	Ensure that prices are kept low (no surge) or provide resources for free to evacuees Allow evacuees to pay for resources (if needed) through multiple payment methods, including cash Provide information on evacuation and reentry resources or assistance organizations (e.g., Red Cross) beforehand
Asset Poor	Have less than $500 in cash assets available for use	Economic	Not available			Asset poor usually have credit cards, which allows them to engage with the sharing economy. With the low cost of transportation and sheltering through shared resources, they may be more likely to evacuate despite the lack of cash. However, they may still not have access to technology and may be subjected to price gouging.	Ensure that prices are kept low (no surge) or provide resources for free to evacuees Allow evacuees to pay for resources (if needed) through multiple payment methods, including credit cards
Racial and Ethnic Minority	Are not in a dominant position and suffer discrimination based on physical and/or cultural traits	Spatial Economic Social	27.9% Non-White-alone) 39.3% Hispanic or Latino			Racial and ethnic minorities are a diverse group of people with a wide range of incomes, education levels, and access to technology. In this case, shared resources via neighbors and sharing economy companies would work well. However, shared resources provided by strangers might be ineffective as these minorities may experience further discrimination as they attempt to request transportation or sheltering.	Increase trust by increasing the vetting process for drivers and hosts Develop neighborhood-based programs that leverage similarities in cultural and social dimensions Train drivers and hosts to provide service to all evacuees, regardless of race or ethnicity Disseminate information in a variety of forms to communities so they gain a better understanding of real threats of the hazard

Older Adults	Age 65 and over	Temporal Economic Physiological Social	13.2% age 65 and over			Given the rising population of older adults, evacuation needs for this group will continue to grow. Older adults would gain the most through point-to-point service and opportunities to maintain social connections. The extra resources may also encourage elderly individuals to evacuate. However, a digital divide exists, and there may be liability concerns related to medical needs. Extra training for providers may also be needed to help older adults move.	Partner with local governments to increase security and safety Ensure that costs remain low Train drivers and hosts to assist older adults in evacuations Ensure information is disseminated across multiple media platforms Ensure that shelters and other housing facilities have necessary medical equipment (e.g., oxygen tanks, access to dialysis centers)
Physically Disabled	Physical impairment that substantially limits major life activity	Temporal Economic Physiological Social	10.2% with some type of disability			Individuals with physical disabilities are often not provided the necessary services or care that is required through civil rights protections. Increased resources, point-to-point service, and increased compliance are all benefits. However, helping these individuals does lead to liability concerns and would require provider training. Accessible vehicles may also not be available.	Create partnerships with paratransit that could identify and assist individuals with disabilities Include an option in digital applications to denote disability or assistive device or animal ownership Train drivers and hosts to assist physically disabled individuals in evacuation situations
Cognitively Disabled	Learning or intellectual impairment that substantially limits development and/or major life activity	Economic Physiological Social	4.2% with some type of disability			Individuals with cognitive disabilities are harder to identify and locate than other disabled individuals. Many often have a caregiver who takes care of them more regularly. Given the difficulties and the lower level of self-sufficiency, cogitatively disabled individuals may not benefit substantially.	Create partnerships with paratransit that could identify and assist individuals with disabilities Include an option in the application to denote disability or assistive device or service animal ownership Train drivers and hosts to assist cognitively disabled individuals

Psychologically Disabled	Psychological impairment that substantially limits major life activity; includes mental conditions	Economic Physiological Social	10.7% with some type of disability			Similar to individuals with cognitive disabilities, individuals with psychological disabilities are harder to identify and locate. This group does include a higher proportion of those who are self-sufficient and engaged with technology. Individuals with psychological disabilities may benefit from social connections through shared resources, especially housing.	Create partnerships with paratransit that could identify and assist individuals with disabilities Include an option in digital applications to denote disability or assistive device or service animal ownership Train drivers and hosts to assist psychologically disabled individuals in evacuation situations
Homebound	Unable to leave home; individuals may also be socially isolated	Spatial Physiological Social	5.5% age 18+ with "independent living difficulties"			Homebound individuals are difficult to identify and locate and they may have additional characteristics (such as having a physical disability). Communicating with these individuals may also pose a challenge. However, these individuals would greatly benefit from point-to-point transportation and the increase of social connections in a disaster.	Create partnerships with paratransit and leverage neighborhood networks that could identify and assist homebound individuals Ensure resource information is disseminated across multiple media platforms
Assisted Living	Located at a nursing home or other similar types of facilities	Spatial Physiological Economic Social	Not available			Assisted living centers may require high-capacity shuttles to effectively evacuate their facilities. Resources through companies may be a more immediate possibility. These centers have also struggled in recent disasters in evacuating residents so any type of shared resources may be effective.	Create partnerships with paratransit and assisted care facilities that could assist evacuees in transportation and find proper shelter with adequate support Prepare go bags for residents with necessary medicine and/or medical information in case of evacuation

Hospital Bound	Located at a hospital due to health reasons; may be permanent or temporary	Spatial Temporal Physiological Economic Social	Not available			Hospitals may require high-capacity shuttles to be able to effectively evacuate their facilities. However, hospitals face additional challenges related to the continuous care of their patients, which the sharing economy would not be able to provide in the form of vehicles or sheltering.	Create partnerships with paratransit and hospitals that could assist evacuees in transportation and find proper shelter with adequate support Prepare go bags for patients with necessary medicine and/or medical information in case of evacuation
Immigrant	From a different country and comes to live permanently; may or may not be a citizen	Spatial Economic Social	27.3% are foreign-born			Immigrants are a diverse group of people with relatively high access to technology. Many immigrants are also well established in their community where they may be able to leverage their resources. Shared resources in the neighborhood is the most straight-forward use case, especially since communication, language, and cultural barriers might exist.	Provide information on available resources multiple languages Include credentialing information for hosts to increase trust Develop neighbor-to-neighbor networks to maximize trust and resource sharing
Undocumented Immigrant	From a different country and do not have legal immigration status	Spatial Economic Social	Not available			Locating undocumented immigrants is very challenging and encouraging them to accept assistance in situations where they may be tracked is difficult. Undocumented immigrants are likely more willing to congregate with friends and family, which would increase social connections.	Provide information on available resources multiple languages Develop neighbor-to-neighbor networks to maximize trust Provide information on resources that are not government sponsored to ease fears of document checks
Non-Native English Speakers	Speak a language other than English (i.e., English as a second language)	Spatial Economic Social	44.6% (Age 5+) do not speak English at home; 6.8% households are limited English-speaking			Non-native English speakers often have difficulty navigating relief programs, which are predominately in English. Pairing and matching by language or using automated translations could be effective in offering services. However, cultural and communication barriers along with discrimination may be a problem.	Provide information on available resources multiple languages Develop neighbor-to-neighbor networks to maximize trust and resource sharing

LGBTQ+	Gender-based and sexuality-based identity	Social	Not available			LGBTQ+ individuals are economically diverse and generally have high access to technology. However, some individuals may experience continued discrimination with shared transportation or sheltering. Adequate matching would help maintain social connections.	Train drivers and hosts to provide service to all evacuees, regardless of sexuality or gender Develop a peer-to-peer network that leverages community similarities
Homeless	Without an established or regular home	Spatial Temporal Physiological Economic Social	Not available	  	 	Increasing the number of resources to raise compliance of orders and decrease costs are the most positive benefits. However, homeless individuals are challenging to locate and much of the public is unlikely to want to engage with the homeless, since they are often equated with psychological issues.	Ensure that prices are kept low (no surge) or provide resources for free to evacuees Leverage pre-existing homeless shelter expertise in finding adequate housing and transportation
Required Workers	Must work, by law, in disaster events	Spatial Temporal	Not available			While not typically viewed as a vulnerable group, required workers may benefit in disasters with designated housing near the disaster area. These individuals have access to technology, but they may be safer in a location away from the disaster.	Encourage community members to provide resources to disaster workers

Legend of Sharing Opportunities

 Increase housing or sheltering resources

 Increase evacuation compliance

 Increase transportation accessibility

 Decrease the cost of transportation or sheltering

 Maintain social connections and decrease psychological impacts

Legend of Sharing Challenges

 Not enough resources available and/or difficulty finding these resources

 Hard to locate individuals

 A digital divide (i.e., low access to technology)

 Increase costs or potential for price gouging

 High liability for the provider of service

 Likelihood for discrimination

 Cultural differences

 Communication challenges stemming from a lack of understanding or an inability to explain services

 Additional training may be required to provide service

 Evacuating may not be the best decision, and sheltering-in-place may be safer

7. CONCLUSION AND RECOMMENDATIONS

This research suggests that clear resource deficiencies remain in evacuating citizens, including those most vulnerable. While the sharing economy could offer more equitable outcomes for disaster response and relief, the STEPS equity framework and focus groups with four vulnerable groups – older adult, individuals with disabilities, low-income, and Spanish-speaking – indicate that a substantial number of limitations remain. Indeed, we found that of the 18 identified vulnerable groups, all face at least one critical challenge in implementing shared resources with 10 groups experiencing three or more barriers to implementation. While some of the barriers could be overcome quickly such as developing partnerships to decrease the potential for price gouging, other challenges such as high liability, the digital divide, and locating vulnerable groups would take considerably more effort and planning on the part of agencies and practitioners.

While numerous challenges remain in developing a comprehensive shared resource strategy, public agencies can still begin to build a more structured framework. Based on the focus group results and a consolidation of recommendations from the STEPS framework (Table 8), we recommend that agencies should consider adding shared resources into strategies for evacuation and sheltering response as seen in Table 9. These recommendations serve as a starting point for building practical strategies and encouraging more research on social equity in this alternative evacuation strategy.

We also note that multiple public agencies and community organizations will need to develop partnerships (or at least working relationships) with sharing economy companies. Several additional items need to be considered in the planning process. First, local areas need to determine if resources from sharing economy companies are even available. These companies often do not operate in rural areas of California (or rural areas in the U.S.). Consequently, a community-based strategy that leverages neighbors and private citizens will be most effective (e.g., carpooling networks, homesharing networks, phone trees, and Community Emergency Response Team (CERT) integration). We note that these community-based strategies should not be restricted to rural areas but are also crucial for disaster preparedness in larger cities and suburban communities. Second, several entities need to be consulted in developing a shared resource strategy. Specifically, law enforcement agencies, such as the state highway patrol, are often responsible for on-the-ground evacuation response and can restrict access to areas where sharing economy vehicles may attempt to go. Finally, the relationships need to be developed with the various agencies (e.g., transportation, public transit, emergency management, firefighting, law enforcement, CBOs, etc.), which may differ by jurisdiction and even by hazard. Flexibility within these relationships is crucial, which is why we recommend beginning with situational awareness and working relationships before developing more structured shared resource partnerships.

Table 9. Recommendations for Public Agencies using the Focus Group Results and STEPS Framework

Literature	Recommendation	Potential Equitable Outcomes	S	T	E	P	S
Vulnerable populations, in particular, may face a severe shortage of resources when trying to evacuate, especially carless and special needs households (Renne et al., 2008). Shared modes (e.g., TNCs) may be used to complete first- and last-mile gaps in the transportation network (Meyer and Shaheen, 2017).	Building more robust public transit-based evacuation plans that leverage the sharing economy for first-mile, last-mile connections and post-disaster transportation	• Provides additional resources for carless, low-income, and transit-reliant individuals • Promotes a faster evacuation (in trip time), especially for those physically unable to evacuate quickly • Assists in decreasing evacuation congestion, thus improving evacuation times	X	X	X	X	
Significant planning is needed to ensure that evacuees have transportation to shelters and access to free resources, particularly vulnerable populations (Litman, 2006; Cahalan and Renne, 2007; Renne et al., 2008). Predetermined pick up points provide easy-to-find locations for evacuating households who need transportation (The City of New Orleans, 2018).	Creating a TNC and/or public transit plan with meeting points for different resources	• Increases the number of rides to shelters • Offers locations for medical attention and free basic necessities (e.g., water, N-95 masks)	X	X	X	X	X
Individuals with disabilities have a variety of different physical and mental conditions, including those that are not readily visible, that inhibit their ability to evacuate (Renne et al., 2008), are less likely to have an evacuation plan (Spence et al., 2007), and are more likely to evacuate later than recommended for hurricanes (Ng et al., 2015). Public transit agencies with their own accessible vehicles or contracts with paratransit operators have some capacity to meet mobility and evacuation needs (SMART Train, 2017; Napa Valley Register, 2017; The City of New Orleans, 2018), but advanced planning is necessary to assist public transit-dependent evacuees (Bish, 2011).	Creating partnerships with paratransit providers to identity and assist individuals with disabilities	• Increases availability of accessible vehicles to allow for spatially broader and faster coverage in an evacuation • Ensures that individuals with disabilities trust drivers and resource providers • Ensures that resources providers are properly trained to assist individuals with disabilities	X	X		X	X
Shared mobility modes may be inaccessible to certain populations due to financial barriers (Shaheen et al., 2016). Services that allow for fare payment in a variety of ways (e.g., cash, through smartphone apps) can increase mobility and	Developing regulations that keep costs of resources low to avoid surging and allowing evacuees to pay for resources (if absolutely	• Improves the ability of low-income, unbanked, and asset poor individuals to use services • Increases evacuee trust of companies			X		X

accessibility for different demographic groups, especially those with limited resources (Shaheen et al., 2017).	necessary) through multiple payment methods including cash						
Evacuees have gone without adequate food, water, prescriptions, and medical care at shelters (Brodie et al., 2006), and individuals with significant medical conditions often do not have guaranteed medical attention at evacuation destinations (Renne et al., 2008). While some shelters during the California wildfires faced considerable difficulties in maintaining quality of life due to capacity challenges and spread of illness, others were able to act as distribution centers for resources and aid during and after the fires (Wong et al., 2020b).	Ensuring that shared shelters and other accommodations have necessary medical equipment (e.g., oxygen tanks, access to dialysis centers) for fire-based health challenges (e.g., smoke inhalation) in addition to medical supplies to treat chronic illnesses (e.g., insulin for people with diabetes)	• Improve health outcomes of older adults, medically fragile populations, and individuals with disabilities			X	X	
Persistent challenges remain in locating and communicating with vulnerable populations, especially those without mobility (Turner et al., 2010). Voluntary and adequately confidential registries (among other tools) can be used by emergency planners to identify vulnerable populations and more easily assist individuals with resources, such as transportation (Hoffman, 2008).	Developing a system within TNC/homesharing applications or a public registry that denotes vulnerable individuals that need extra physical assistance, have a disability, and/or own a pet/service animal	• Increases knowledge of vulnerable individuals' locations and assistance needs • Improves reaction time of resource providers to reach vulnerable populations	X	X	X	X	X
Neighbors are a common source of receiving information during wildfires (Wong et al., 2020b), especially given that communication may be unavailable (Wong et al., 2020b). Indeed, only 56% and 71% of households with incomes under $30,000 have access to broadband Internet and smartphones, respectively (Pew Research, 2019a,b). Social cohesion, in particular characteristics such as sense of community and collective problem solving, increases preparedness and reduces vulnerabilities in wildfires (Prior and Eriksen, 2013), while social networks influence evacuation choice in hurricanes (Sadri et al., 2017).	Working with neighborhood associations to develop localized community-based plans to ensure transportation for neighbors	• Offers a more trustworthy (and maybe more effective) strategy for all vulnerable groups • Provides more evacuation options and resources for neighbors					X
Non-English speakers and ethnic minorities face challenges in receiving and understanding warning messages (Perry, 1987);	Providing resource information (and	• Ensures information is understood by non-English speakers		X			X

sometimes receive warnings in other languages later than English warnings in wildfires (Shyong, 2019); and face language and cultural barriers in accessing post-disaster funding and shelter (Cutter et al., 2003). Disseminating information in a variety of forms and languages can spread awareness and understanding of evacuation orders (Perry, 1987), and lessons can be learned from multi-language outreach by public transit agencies (Turner et al., 2010).	evacuation orders) in multiple languages and through multiple channels	• Improves the speed of information dissemination in non-English speaking communities and ethnic enclaves • Improves trust between non-English speaking communities and public agencies					
Lack of trust can be a barrier to exchanging goods and services via the sharing economy under normal conditions (Mohlmann, 2015; Hamari et al., 2016). Risk perceptions have been found to influence wildfire evacuation behavior (McCaffrey et al., 2018; Toledo et al., 2018; Lovreglio et al., 2019), higher trust levels (as opposed to lower levels) prior to a disaster lead to a larger trust-increasing effect after the disaster (Dussaillant and Guzman, 2014), and setting credentials for shared mobility can increase trust (Taylor, 2019).	Increasing credentialing of drivers and host for both companies and private providers	• Increases evacuee trust of shared resources companies and providers					X
Most large U.S. cities do not have adequate plans to assist and evacuate carless and vulnerable populations (Renne and Mayorga, 2018) and many vulnerable populations are unable to evacuate on their own (Renne et al., 2008). Social cohesion increases psycho-social and material support to community members, which helps increase protective action in a wildfire (Prior and Eriksen, 2013).	Offering training through Community Emergency Response Teams (CERTs) or other organization in how to properly assist others in evacuations	• Ensures that providers safely assist vulnerable populations • Reduces potential liability on providers and companies • Decreases likelihood of discrimination against vulnerable populations • Improves safety of providers and individuals' willingness to assist in evacuations			X		X
A significant gap exists between perceived disaster preparedness and actually taking steps to prepare (e.g., owning items for emergencies such as canned goods, flashlights, and "go bags") (Ablah et al., 2009). Furthermore, hospitals and other healthcare facilities have faced significant challenges in successfully evacuating patients (Fink, 2013). "Go bags" for emergencies can better prepare individuals, particularly those who face additional risks, such as medical conditions (Gusmano and Rodwin, 2010), and hospitals and	Requiring assisted-care centers and hospitals to prepare go bags for patients with necessary medicine and medical information	• Smooths and speeds up the evacuation process (especially for a TNC-based evacuation) • Improves continuity of care for patients and health outcomes		X		X	

healthcare facilities have successfully evacuated from wildfires (Espinoza and Kovney, 2017).							
Cultural and language barriers along with communication method can negatively impact the rapid dissemination of information to vulnerable populations (Turner et al., 2010). Agencies have struggled to communicate evacuation orders and resources effectively during wildfires due to the speed that fires travel (Wong et al., 2020b). Communicating information, such as resource availability, using public education methods and best practices from public transit agencies can help to overcome some (but not all) communication barriers with vulnerable populations (Turner et al., 2010).	Disseminating information about resources (e.g., assistance filing insurance claims, TNC or public transit rides, free air masks) prior to evacuations and during the reentry phase through both government agencies and CBOs	• Improves long-term economic and health outcomes for impacted evacuees, especially high-risk populations • Offers a pathway for undocumented immigrants to gain needed resources without fear of document checks • Improves reentry process and subsequent access to resources			X	X	X
Different disasters, with varying geographical scales and warnings, have major transportation issues including: evacuating people, supplying emergency services (including personnel to assist), and transporting search and rescue teams (Litman, 2006). Companies have worked to create mechanisms for helping disaster workers, such as actions by Airbnb to sign memoranda of understanding with cities and create a disaster response programs to house both evacuees and disaster workers (Wong et al., 2020b). Local citizens provide much needed surge capacity and assistance through informal volunteerism (Whittaker et al., 2015).	Encouraging community members to offer transportation and sheltering assistance to required and disaster workers	• Allows workers to remain close to the disaster to improve response • Improves trust and relationships between community members and disasters workers	X	X			X
Vulnerable populations face considerable needs, barriers, and challenges in receiving communications and evacuating during disasters (Cahalan and Renne, 2007; Renne et al., 2008; Turner et al., 2010). Strengthening participatory planning approaches that analyze risks and vulnerabilities (among other strategies) can reduce disaster impacts on communities and increase resilience (UNDRR, 2011).	Including all vulnerable groups in the planning process for emergency evacuations	• Increases the input of vulnerable groups in evacuation plans and increases equitable outcomes for those groups • Provides resources that may be useful for a variety of vulnerable groups	X	X	X	X	X

In addition, we offer several key research directions for continued work in this sub-field of evacuations. These research recommendations are not meant to encompass the entire field of evacuations but serve as a primer for future work that could build off of this research.

- Measure the number of current sharing economy assets and the availability of assets during emergency conditions;
- Determine the risk perception of individual providers and users in the sharing economy in cases of disasters;
- Study the capacity of other sharing economy assets that could increase social equity and improve outcomes such as:
    - Bikesharing – on-demand access to bicycles at a variety of pick-up and drop-off locations for one-way or roundtrip travel;
    - Carpooling – grouping of travelers into a private automobile for trips between home and work locations or for trips that would have otherwise occurred;
    - Carsharing – short-term access to automobiles, allowing users to gain the benefits of a private automobile while forgoing auto ownership costs;
    - Scooter Sharing – on-demand access to electric scooters at a variety of pick-up and drop-off locations for one-way or roundtrip travel;
- Focus additional research on the sharing economy to cover small-scale evacuations, non-hurricane evacuations, and rural evacuations; and
- Consider the role of innovative mobility beyond the sharing economy, including electric vehicles, automated vehicles, and urban air mobility (e.g., automated and electric helicopters), and how these new modes could improve (or harm) social equity outcomes.

Finally, we note that a clear next step for this research would be to conduct an extensive survey of vulnerable individuals who were impacted by the California wildfires and additional focus groups for the same groups and other vulnerable groups. This would likely require a combination of survey methods to reach all individuals, particularly those who were displaced. Future surveys should also take cues from recent work on social capital and social networks in evacuations (Sadri et al., 2017; Sadri et al., 2018). Indeed, the feasibility of the sharing economy strategy likely rests on the strength of social capital in the community, as we found in the requirements of trust in the focus groups. Moreover, we note that the sharing economy will require strong communication mechanisms including a mixture of high-tech strategies (e.g., social media) and low-tech strategies (e.g., face-to-face interactions). Research has found that social networks can impact joint decision-making for regular travel (Sadri et al., 2015) and large-event travel (Rezende et al., 2016). Other research on disasters and large events also have found the presence of the "power law," where fewer nodes can be highly influential in disseminating information (Sadri et al., 2019). This indicates that any future sharing economy model could make use of several key people in the community to increase resources. Social media can also be used to determine resource needs (Ukkusuri et al., 2014) and be extended to the present topic of the sharing economy as a primary mechanism for matching. Finally, other sharing economy research, such as Borowski and Stathopoulos (2020), should continue to address TNCs for evacuations from a much-needed demand perspective using mode choice modeling. With this growing interest in shared resource mechanisms, a multi-method approach that leverages both stated preference and revealed preference surveys from both non-evacuees and evacuees will be critical in determining how capacity and demand for shared resources can improve equitable outcomes.

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9. AUTHOR CONTRIBUTIONS

Stephen Wong: Conceptualization, Methodology, Investigation, Data Curation, Writing – Original draft preparation, Writing – Reviewing and Editing, Project Administration

Jacquelyn Broader: Investigation, Data Curation, Writing – Original draft preparation, Writing – Reviewing and Editing

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